KECHIKA ENHANCEMENT PROJECT OF NORTHEASTERN B.C. WOLF/UNGULATE MANAGEMENT 1984-85 ANNUAL REPORT

Ministry of Environment
Wildlife Branch
Fort St. John, B.C.

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OF NORTHEASTERN B.C.

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by
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ABSTRACT

This report identifies work completed for the Kechika wolf/ungulate management program for the 1984/85 biological year. Wolf and ungulate population responses to wolf removal are documented; 157 wolves, or 65% of the 1985 prereduction estimate, were removed from the reduction area. Moose in the reduction area have responded to lower wolf numbers with 12 times as many calves per 100 cows as moose in the untreated wolf area. Indeed, if moose calf proportions were examined for the Kechika, 90% of the variation was statistically explicable by the number of wolves present.

Mountain sheep in the reduction area responded to lower wolf numbers with twice as many lambs and five times as many yearlings per ewe as mountain sheep in the untreated wolf area. Caribou losses biased to calves were identified for two periods neonatal and over-summer. Neonatal calf losses were largely dependent upon concentration of the calving grounds by spring snowpacks with attendant losses to predation being higher the greater the concentration; 83% of the year-to-year variation was explained statistically in this manner. Over-summer calf losses appeared to relate in a direct manner to the number of wolves present with 86% of the variation explicable by wolf numbers. A larger reduction area appeared to provide a number of improvements in effectiveness, while still ensuring maintenance of a viable wolf population.

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INTRODUCTION

Ungulates have co-existed with wolves for thousands of years. Thus, it follows that there are natural mechanisms which allow mountain sheep, moose, and other ungulate populations to survive at least at minimal numbers in the face of wolf predation. Unfortunately, there are no longer systems uninfluenced by man. Further, escape of ungulates from population control by wolves appears to be infrequent and short-lived in the absence of wolf control (Bergerud 1983; Mech and Karns 1977; Keith 1983). While in some cases, ungulate declines may be triggered by weather or man's influence, wolf predation alone appears sufficient to maintain a downward slide of ungulate numbers (Gasaway et al. 1984). High or even moderate densities of ungulates and wolves are not maintainable without some form of occasional wolf reduction.

Ungulate declines in northeastern B.C. (Elliott 1982a, 1984) have been extensive and severe, impacting on hunters desiring to use wildlife as a food source as well as on residents who depend on them for employment, study or enjoyment.

The key indicator identified in the declines was widespread low juvenile recruitment relative to adult mortality, with wolves implicated as one of the most likely causative factors (Bergerud 1978; Elliott et al. 1984). Consequently, the Kechika Enhancement Project was initiated to test the effectiveness of wolf control as a method of increasing recruitment and, in time, ungulate numbers.

This report provides an update of the project that examines the role of wolf predation in the declines of moose and mountain sheep in the Kechika area of northeastern B.C. It specifically describes work completed during the 1984/85 fiscal year and wolf/ungulate population responses to treatment. Reports on the three previous years of work are presented in Elliott and Webster (1982a), Elliott (1982), and Elliott (1983). A revised project working plan is available (Elliott 1984). Figure 1 indicates the location of areas referenced in the report.

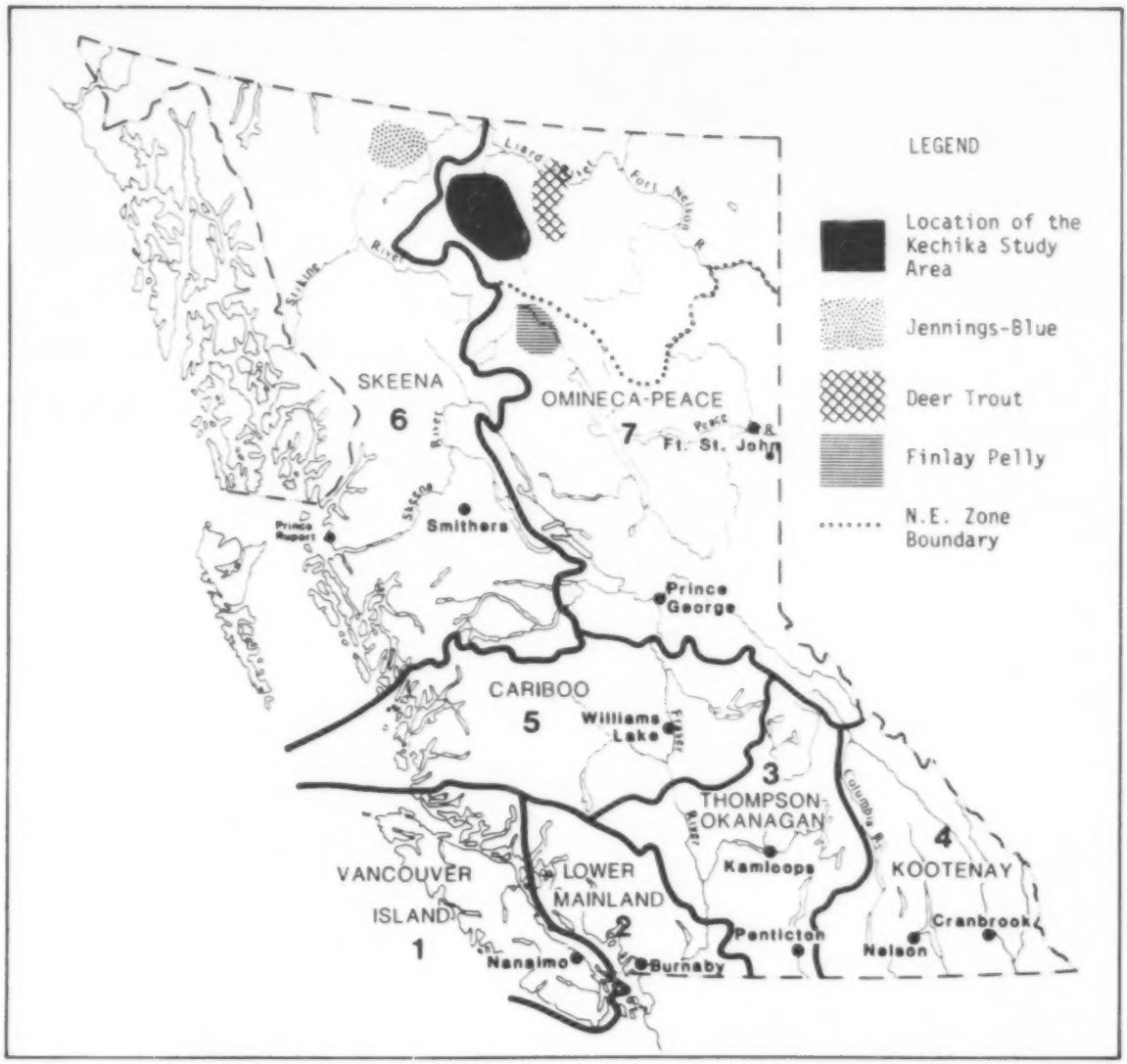

Figure 1. Map of British Columbia showing the location of areas referred to in the text and the zonal NE administration boundary.

METHODS

EXPERIMENTAL DESIGN AND DEFINITIONS

Primarily, the design was a comparison of differing treatments over time. However, comparison between areas during the same time period was also employed to further clarify interactions. The wolf removal area is now the full project size as specified in the revised working plan (Elliott 1984).

Beginning in 1985 the Blue-Jennings area was used as comparison area for moose and mountain sheep. Results from a cooperative Parks Branch - Wildlife Branch Survey in Spatsizi provided a separate comparison for caribou.

Recruitment in this report is defined as the proportion of a population of a given age or older, for one or both sexes, which that given age group comprises. Thus, for example, the recruitment (R) of ten-month calves of both sexes is calculated from field ratios obtained when calves are ten-months-old by the formula:

$$R = \frac{\text{calves}}{\text{calves \& adults}}$$

Similarily, the recruitment of 18-month female yearlings is calculated from field ratios obtained when yearlings are 18-months-old by the formula:

$$R = \frac{\text{female yearlings}}{\text{female yearlings \& adult cows}}$$

The finite rate of population increase (λ) can be calculated from recruitment and mortality beyond the age of recruitment (M) by the formula:

$$\lambda = \frac{1 - M}{1 - R}$$

WOLF SURVEYS AND REDUCTION

Wolves were primarily removed in February-March from progressively increasing portions of the study area in 1982, 1983, 1984, and 1985 (Fig. 2). Incidental removal of wolves also occurred earlier in the winter during other work.

Wolves were inventoried and removed using both fixed-wing and helicopter. Inventory proceeded by flying grids of likely wolf travel routes until fresh sign was spotted. Trails were then followed until either the wolves were seen, or the tracks separated sufficiently to enable a count. When necessary, track counts were confirmed by landing and examining the sign in detail.

Wolf removal was undertaken by government personnel from a Bell 206 helicopter. Conventional shotguns loaded with SSG shot were used. Wolf density was to be reduced to one wolf/260 to 390 km^2 (100 to 150 mi^2) or to approximately 20% of the pre-reduction numbers. This density was chosen to allow clear response identification, yet maintain a substantial minimum wolf population. Areas where wolves were removed are referred to as "reduction" areas, while test-control areas, where wolves were not removed, are referred to as "untreated" areas throughout the text and in tables.

Methodology for recruitment and population estimates has remained consistent through the study to date.

MOOSE SURVEYS

Transects were flown in the autumn and late winter periods each year to estimate the age and adult sex ratios of moose. Transects were uniformly spaced, straight lines (modified where necessary for feasibility in rough topography) and predetermined on 1:250 000 topographic maps. It was felt that this sampling pattern would be random relative to moose distribution. In the autumn, moose were classified as calf, yearling male, adult male, or non-calf female based upon size, presence or absence of antlers, and antler configuration. In winter, they were classified as to calf, non-calf male, or non-calf female based upon shape, size, presence or absence of white vulval hair, head colouration, and presence or absence of antler scars. The proportion of yearlings (both sexes) was estimated by doubling the number of yearling males classified, thus assuming a 50:50 sex ratio.

Autumn transects were flown by fixed-wing or helicopter, while all late winter transects (when the animals were antlerless and thus difficult to classify) were flown by helicopter under relatively favourable visibility and snow cover conditions. The proportion of the total moose population seen was not measured, but it was assumed that there was no visibility bias for the different age/sex categories, except as noted in the results.

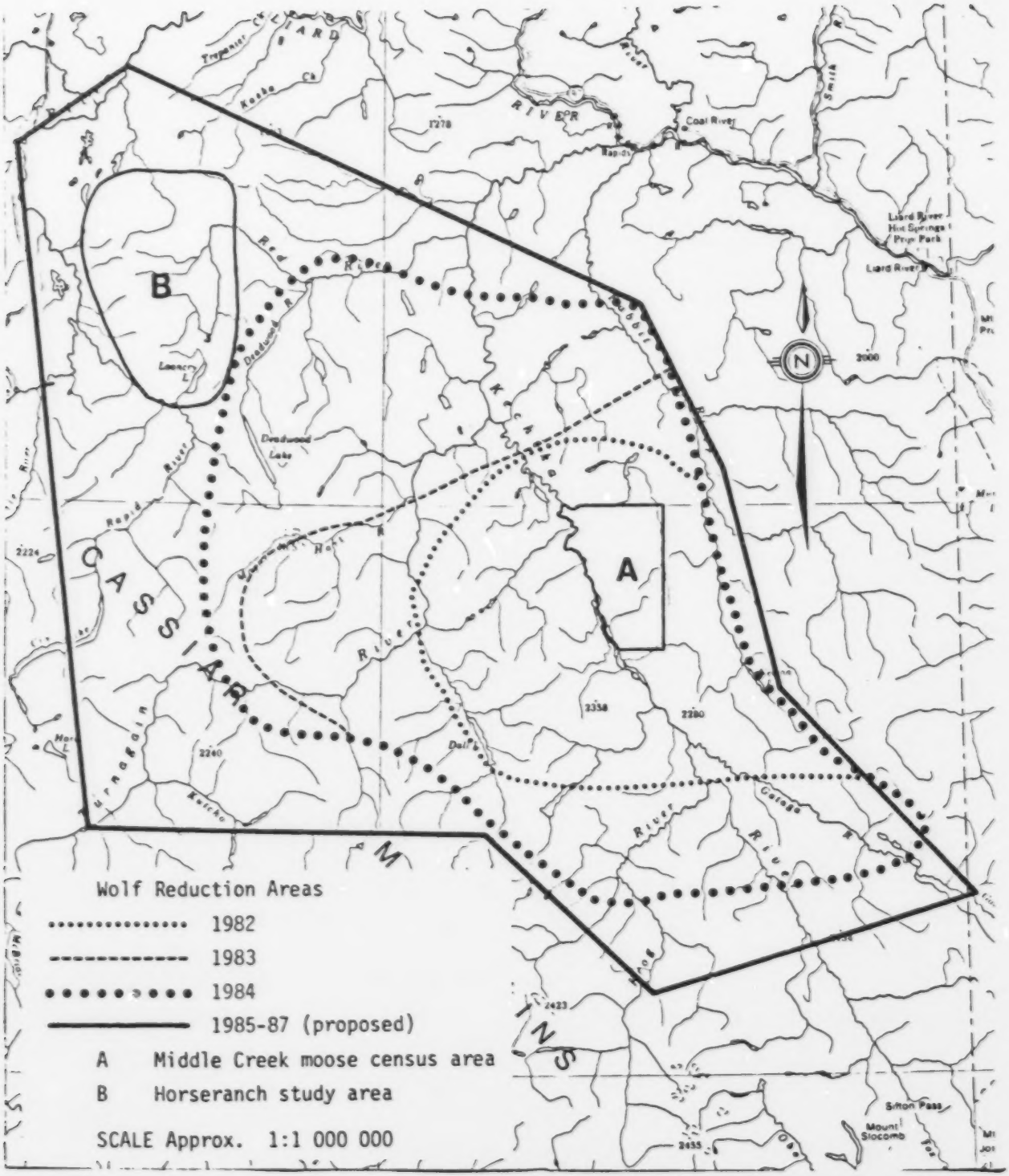

Figure 2. Map of the Kechika study area showing the past and proposed areas for wolf reduction, the Horseranch study area of Elliott et al (1984), and the Middle Creek moose density survey area.

MOUNTAIN SHEEP SURVEYS

All mountain sheep habitat types over differing elevations and aspects were searched for discrete mountain units in an attempt to locate all adult females and juveniles per unit. Juveniles were classified as either 9 months or 21 months old. The wide distribution and smaller group sizes of males made it impractical to aim for a total count for this component outside of the ewe-juvenile areas.

Mountain sheep were inventoried using a Bell 206 helicopter on clear, calm days, with temperatures around -20C. This machine was equipped with bubble windows in the rear and an internal communication system. Speed and closeness were varied so that both observers were placed optimally according to the visibility.

Upon locating a group, the helicopter approached slowly, usually from slightly below or behind the sheep, while the observers obtained a total count. Particularly where the sheep were in open terrain, the approach usually caused them to move upslope in a line or separate into small groups facilitating classification. In rough terrain, the sheep tended to group together and a close (20 to 30 m), slow approach was required to separate them for classification. Where large groups of sheep were encountered, they were classified from the ground using a spotting scope.

In the event fresh sign was observed and sheep were not located, local searching intensity was increased until the group was located. The openness of most of the ranges plus snow cover made this a useful technique.

CARIBOU SURVEYS

Caribou were surveyed during October, when they concentrated for rut. The rutting mountains were surveyed with parallel contours from a Bell 206 helicopter. Flight speed during searching approximated 100 km/hr (70 mph). Once located, animals were observed at close range from the rear to allow sex and age identification.

Animals were classified as to bulls, cows, and calves. Calves were distinguished on the basis of size and antler status. Sex was determined by the presence or absence of the vulva.

Sightability was felt to be highest for animals in the alpine but less for those in timber. Track sign was pursued to increase sightability.

RESULTS AND DISCUSSIONS

WOLF SURVEY AND REDUCTION

In 1982, seventy-one wolves, out of an estimated 88, were encountered in nine packs in the reduction area; 70 (80%) of these were removed (Table 1; Fig. 3). In 1983, seventeen packs and five singles were encountered, for a total of 95 wolves, in the reduction area, out of an estimated 107; 89 (83%) of these were removed (Table 1; Fig. 4). In 1984, out of an estimated total of 138 wolves, 106 were encountered in the reduction area; 101 (73%) were removed (Table 1; Fig. 5).

In 1985, out of an estimated 242 wolves, 165 were encountered in the reduction area and 157 (65%) were removed (Table 2; Fig. 6). The boundary of the project area for much of its length corresponds to landforms which have been found to serve as pack boundaries. There are, however, a number of segments where this is not so. This is especially true for the southwest corner where extension to the height of land would, in retrospect, have been more appropriate. The larger pack of 26 indicated in Figure 7 appeared, based upon sign, to spend substantial time just out of the defined project area and indeed was encountered outside on two occassions. As it was not encountered within the defined project area, it was not removed. If this pack is excluded from the post reduction density estimate then the density would be one wolf per 312 km^2 (120 mi^2), which is within the desired range.

Enlarging the wolf removal area in 1984 appeared to lower the wolf density the next winter (Table 2). This further supported the hypothesis (Elliott, 1984) that the annyual rebuilding of wolf numbers results primarily from immigration into the removal area. Indeed the adjacent area (non 1984 removal area) shows a small decline in wolf numbers over the previous year.

Total cost, (aircraft, fuel, equipment, travel) per wolf, removed remained at the level of the previous four years at $140.00 per animal removed.

One drawback to removing wolves from an area surrounded by a large area of substantial wolf numbers is the need to continue some removal each year. As can be seen from the decreasing 12 month (since reduction) density, as the reduction area is increased, the ongoing costs per unit area decrease. Thus efficiency increases. As we shall see effectiveness also increase.

Figure 7 and Table 3 summarize the 1985 wolf numbers for the Blue-Jennings comparison area. Densities are similar to those of the 1984 untreated area in the Kechika (Table 2).

The percentage of black wolves seen in the removal area changed among years. In 1985, 47% of the 160 wolves seen were grey, while the remaining 53% were black. This contrasts with 19% black wolves in 1982 (N=71), 60% in 1983 (N=95), and 49% in 1984 (N=106). Thus the proportion of blacks have substantially increased from before wolf reduction in 1982.

Sex ratios of wolves removed remained essentially constant during the removal program; 12 (44%) of 27 wolves of known sex in 1985 were females.

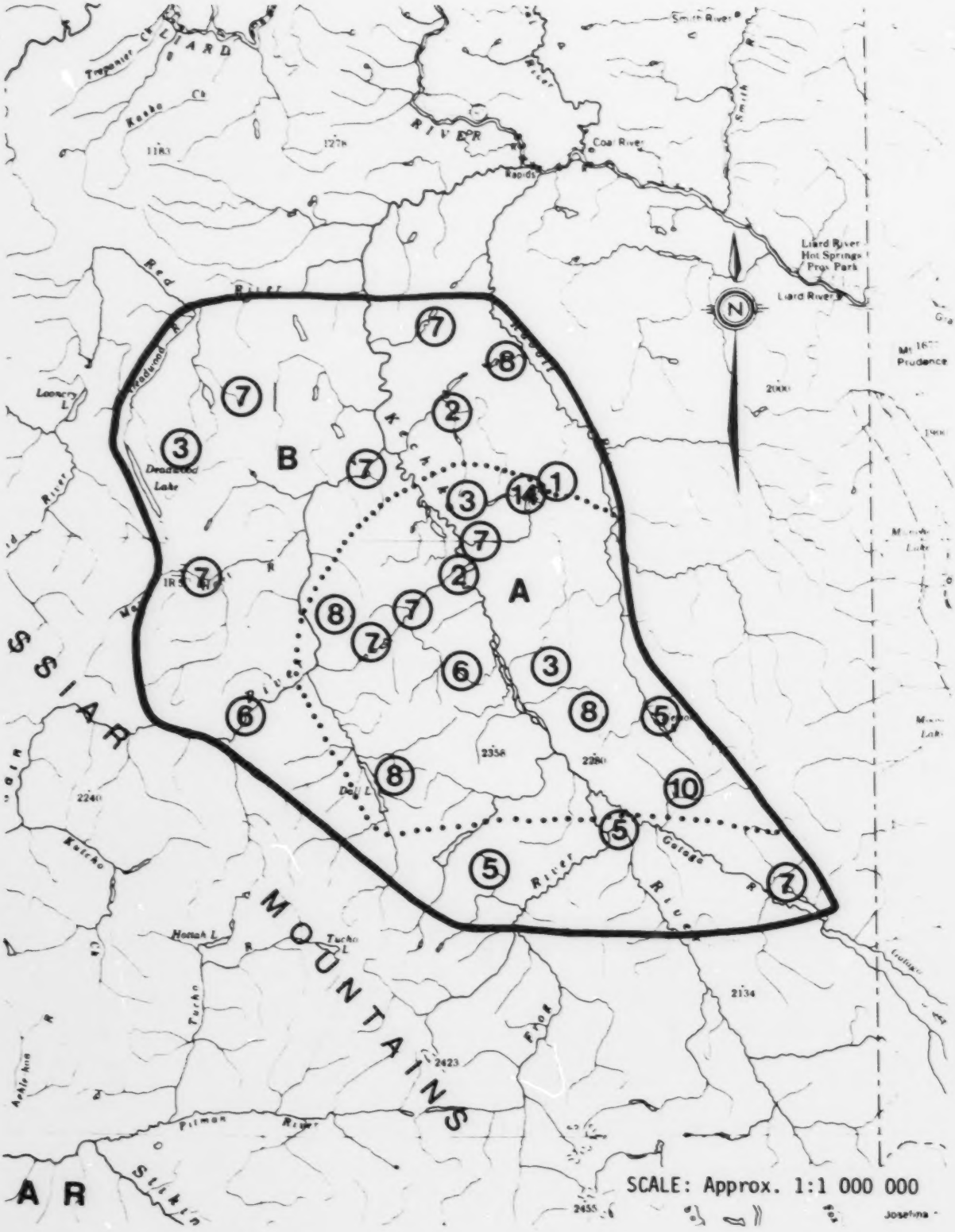

Figure 3. Wolf pack sizes prior to reduction - 1982 (A: wolf reduction area; B: untreated area).

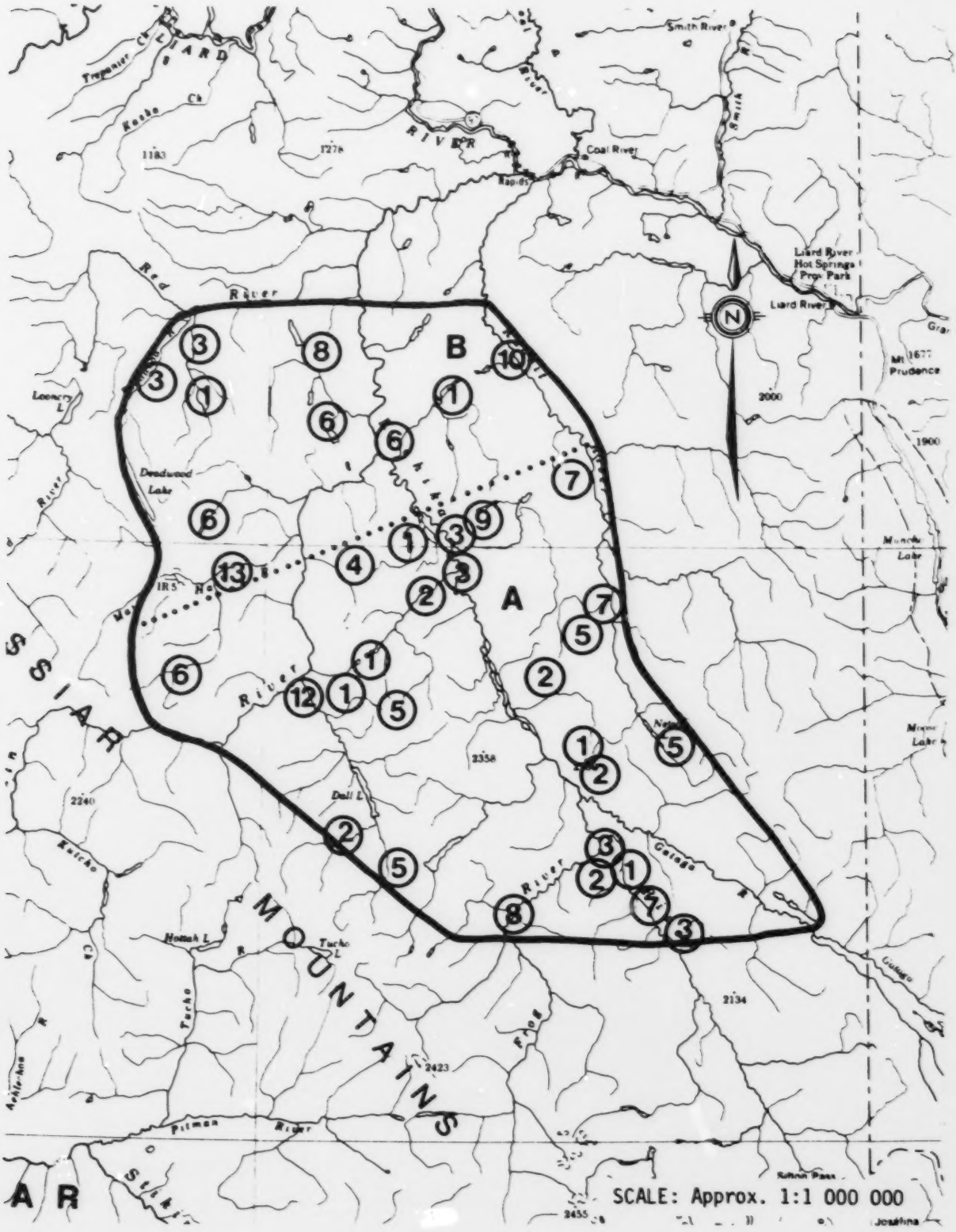

Figure 4. 1983 wolf pack sizes prior to reduction (A: wolf reduction area; B: untreated area).

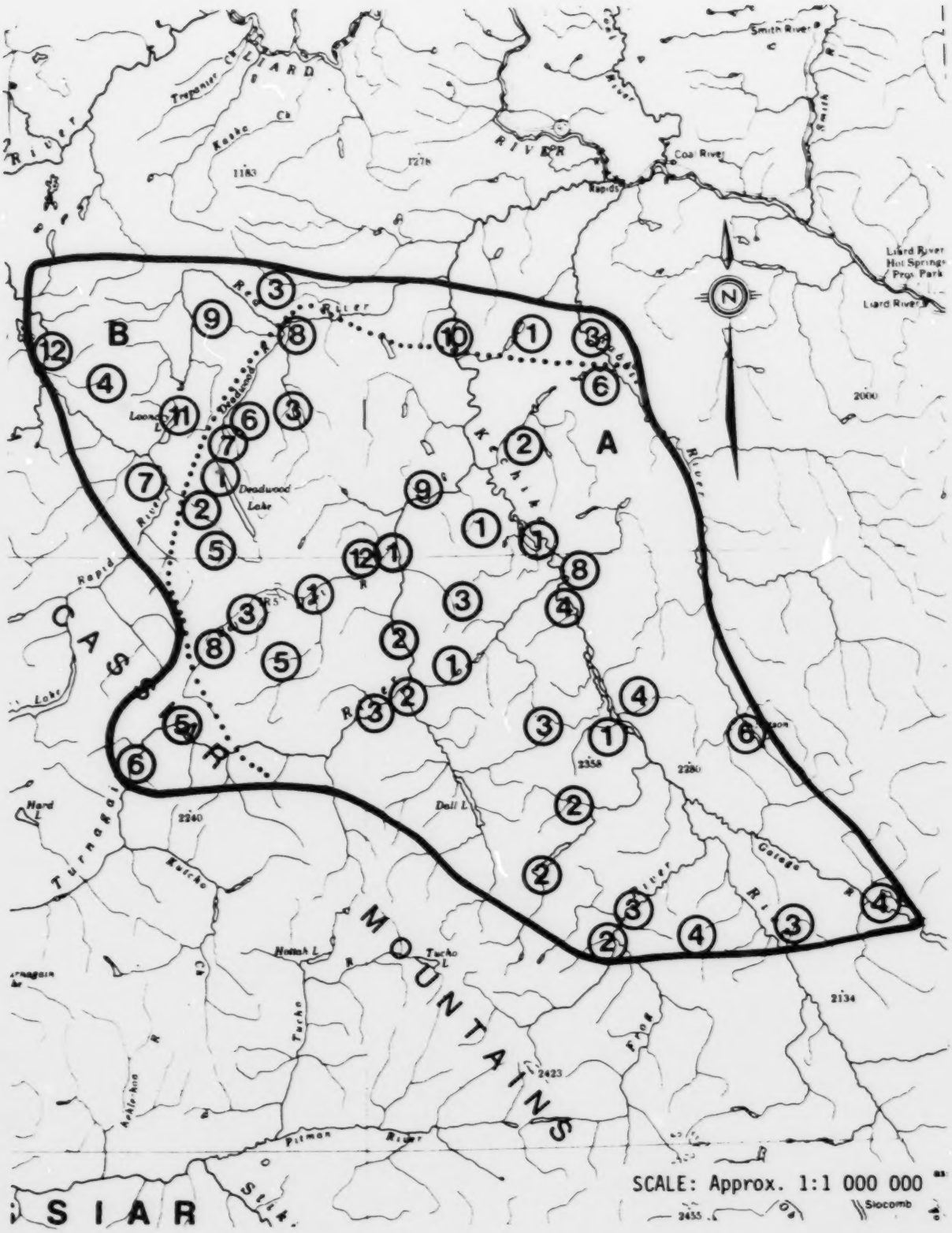

Figure 5. Wolf pack sizes prior to reduction - 1984 (A: wolf reduction area; B: untreated area).

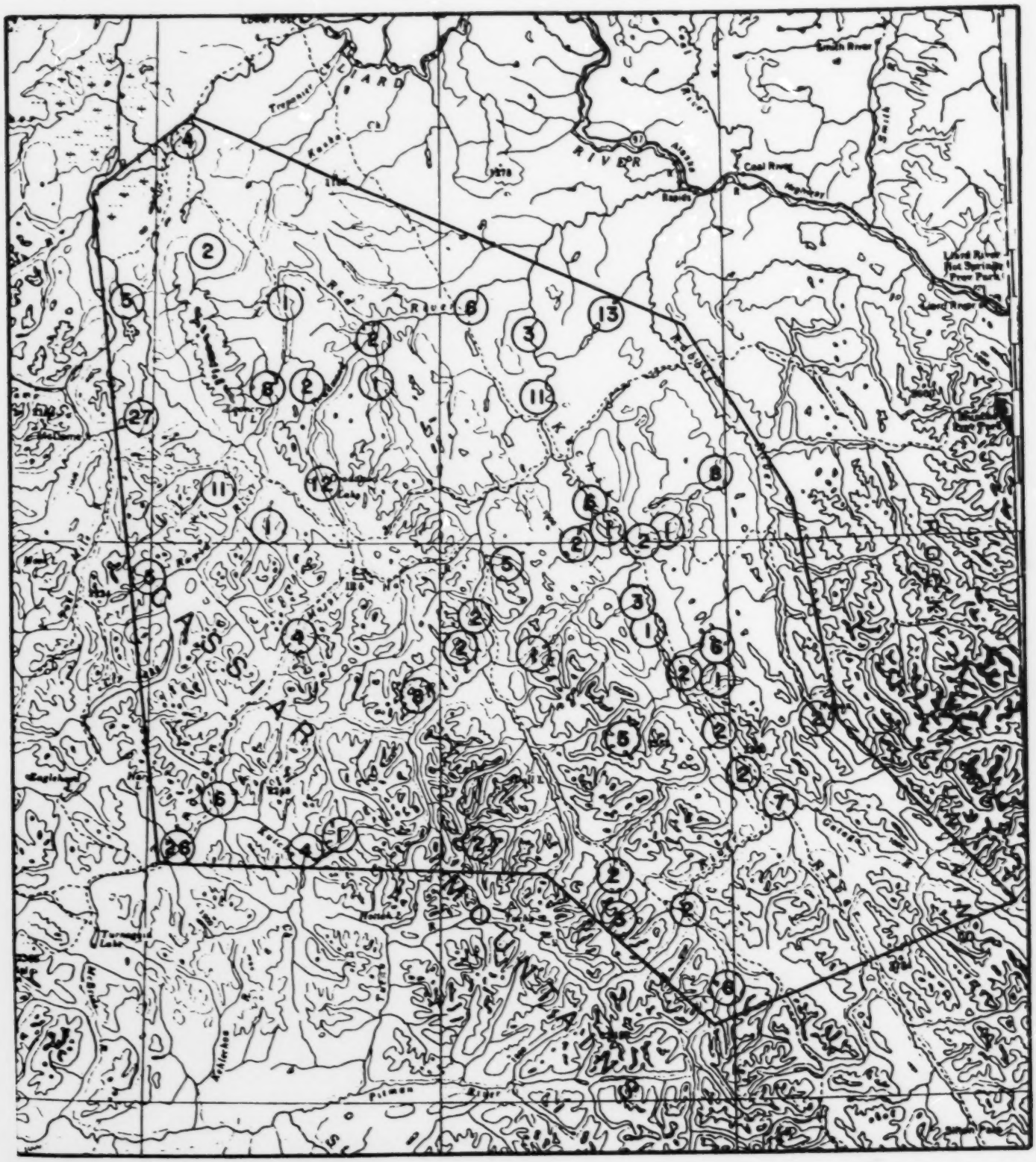

Figure 6. 1985 wolf pack sizes prior to reduction in the Kechika

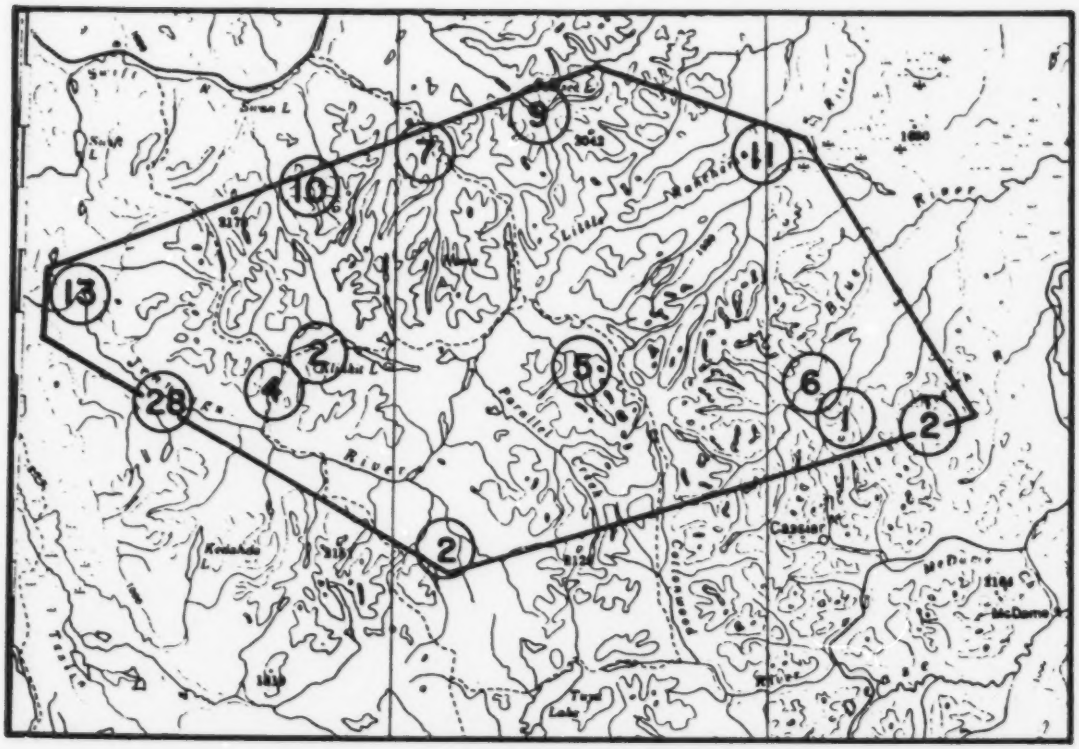

Figure 7. Wolf pack sizes for the Blue Jennings area, 1985

This compared to 49% in 1982, 47% in 1983, and 31% in 1984. In 1985, 36% of the gray wolves and 54% of the black wolves were female. Five (19%) of 27 wolves of known age were young-of-the-year.

MOOSE SURVEYS

The moose survey can be separated into three strata:

1. The area that has had reduced wolf numbers prior to 1984 and thus should show a response in both calf and yearling proportions.

2. The area that has had reduced wolf numbers only since 1984 and thus should show a full response, but not for the calf proportion.

3. The untreated area that has had high wolf numbers all along and should exhibit juvenile proportions resulting from heavy predation.

Table 4 (a and b) examines the autumn proportions of these three areas. The several year (pre-1984) reduction area had eight times the proportion of moose calves and five times the proportion of moose yearlings as the regular high wolf area. The one-year (1984 extension) reduction area had five times the proportion of moose calves found in the regular high wolf area. Yearling moose proportions were similar for the one-year reduction area to those in the regular high wolf area. (Both were higher than expected, probably due to the high mobility of this age class with resultant immigration from the previous years' reduction area.) Calf moose proportions were similar for the two reduction areas.

Table 5 (a and b) examines winter calf proportions of the three areas. The two wolf-reduced areas were similar to each other but with 8- to 12-times more calves proportionally than the high wolf density Blue-Jennings non reduction area.

Table 6 examines the changes over time for the three areas. The increases in calf proportions following wolf reduction were dramatic. Further, if the calf proportions were compared to the wolf numbers independent of location, a correlation was apparent ($r = 0.95$; $df = 7$; $p < .001$; Fig. 8). Indeed, 90% of the variation in calf proportions was statistically explicable by variations in wolf densities. Equation A defines the best-fit transformed linear dependence:

A. moose calves per 100 adult cows = $(\sin (12.0 + [0.1 * \text{km}^2 \text{ per wolf}]))^2 * 100$

MOUNTAIN SHEEP SURVEYS

Table 7a presents results of the 1985 late winter mountain sheep surveys in the Kechika and Blue-Jennings. The survey areas were divided on the basis of the time extent of wolf reduction (see Figs. 4 through 7). The original wolf reduction area had twice the number of lambs and five times the proportional number of yearlings found in the untreated wolf area. The 1984 wolf reduction extension showed similar high lamb numbers and, even with a low lamb input from the prereduction period, still showed three times the yearling proportion found in the untreated wolf area. The 1985 reduction

extension (that is, high wolf numbers during the recruitment period) showed a similar poor status to that of the Blue-Jennings non reduction wolf area. Table 7b shows these differences are significant.

CARIBOU SURVEYS

The Horseranch Range is included in the 1984 wolf reduction area. This area is utilized by a substantial herd of caribou. Table 8 presents results of the 1984 autumn caribou survey of the Horseranch Range; these values require some historical perspective. Table 9 presents autumn data for that herd since 1978; these data also require further examination. Table 10 presents data for five years of observed neonatal (mid-June) calf proportions for the Horseranch Range caribou herd plus Dease Lake spring snowpacks (given as a percent of 18 year average). There was a close correlation ($r = -0.913$ with the proportion transformed with an arc sine) between the proportion of calves and the snowpack. Indeed, 83% of the variation in calf proportions was accounted for by snowpack. The following equation (B) defines the best-fit normalized linear dependence:

B. Caribou calves per 100 cows = $[\sin (49.56 - (0.18 + \text{snowpack})])^2 * 100$

Bergerud et al. (in prep.) present the hypothesis that this relationship results from snowpack affecting the ability of the cows to disperse on the calving grounds which in turn affects the calves' vulnerability to predation. Thus, with low snowpack, the cows disperse widely at parturition, and thereby slow predation by wolves; therefore, their predation level is low. With heavy snowpack, the cows are concentrated, the calves are easy to find, and predation level is high. Bergerud et al. (op. cit.) speculates that this effect is partially independent of predator numbers.

Using equation B, it was possible to calculate the expected neonatal calf proportions for 1983 and 1984. These are presented in Table 11. The neonatal calf numbers from Tables 10 and 11 can then be contrasted to the fall calf numbers (Table 9) to estimate summer survival, which can be related to wolf numbers. Table 12 examines this relationship using the number of wolves that, in March, include the Horseranch Range in their travel area. (The spring surveys may slightly underestimate calf proportions, which is supported by the overly high value for 1980; thus, the neonatal loss is slightly overestimated and the summer loss slightly underestimated (Elliott et al. 1984)). There was a close negative correlation ($r = -0.93$; $df = 5$; $p = .003$; (Fig. 9), with the proportion normalized with an arc sine) between the summer survival of caribou calves and the number of wolves. Indeed, 86% of the variation in summer survival was accounted for by wolf numbers. This close fit supports the validity of using late winter wolf numbers in an analysis of summer predation by wolves. The relation between the two (best-fit normalized linear) can be defined by the equation (C):

C. % summer caribou calf survival = $(\sin * 88.26 - (3.31 * \text{number of wolves})) * 107$

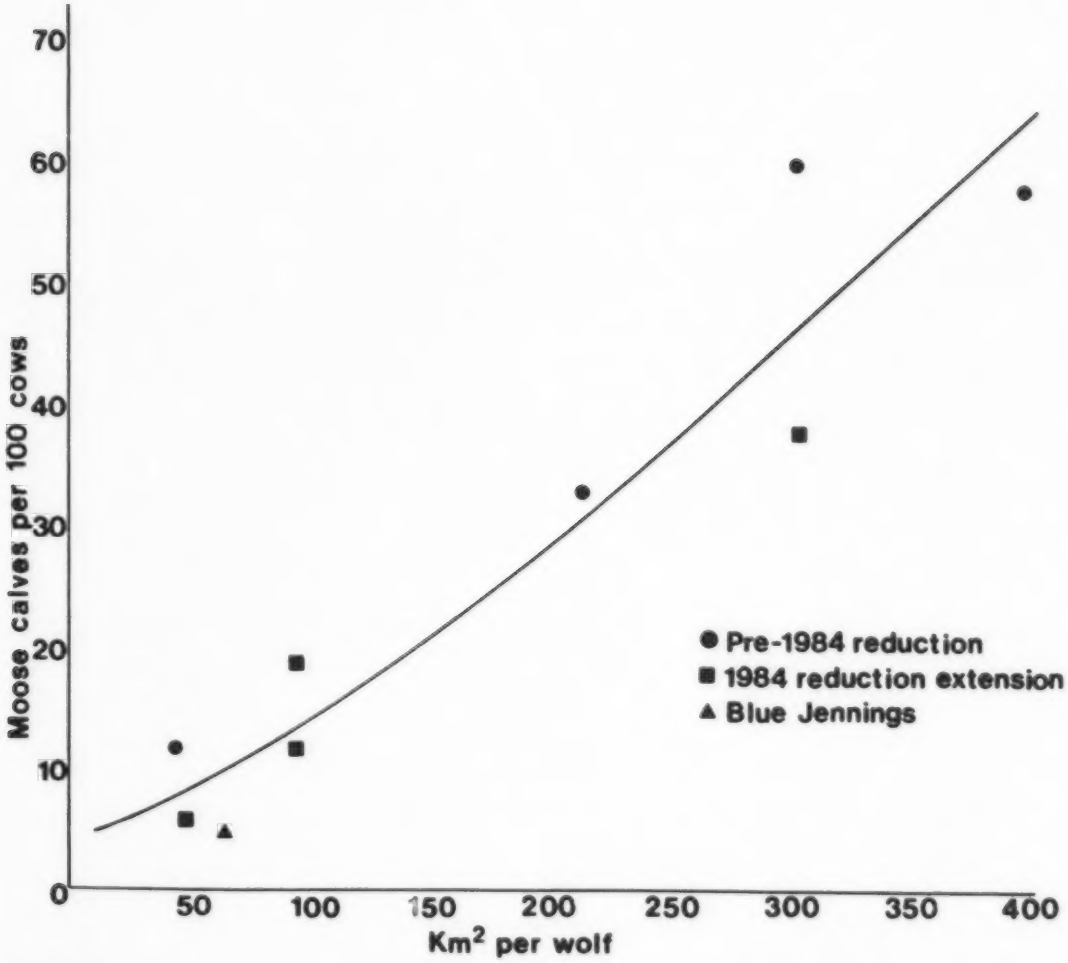

Figure 8. Relationship between moose calves:100 cows and wolf density.

Caribou proportions in the Spatsizi area could be compared with the 1984 proportions of the Horseranch. Table 13 presents those values (I. Hatter, pers. comm.). The proportions are very similar to those of the Horseranch as would be expected with similar conditions, low spring snowpack and unaltered wolf numbers. Reliable estimates of the number of wolves in the Spatsizi area, however, are not available.

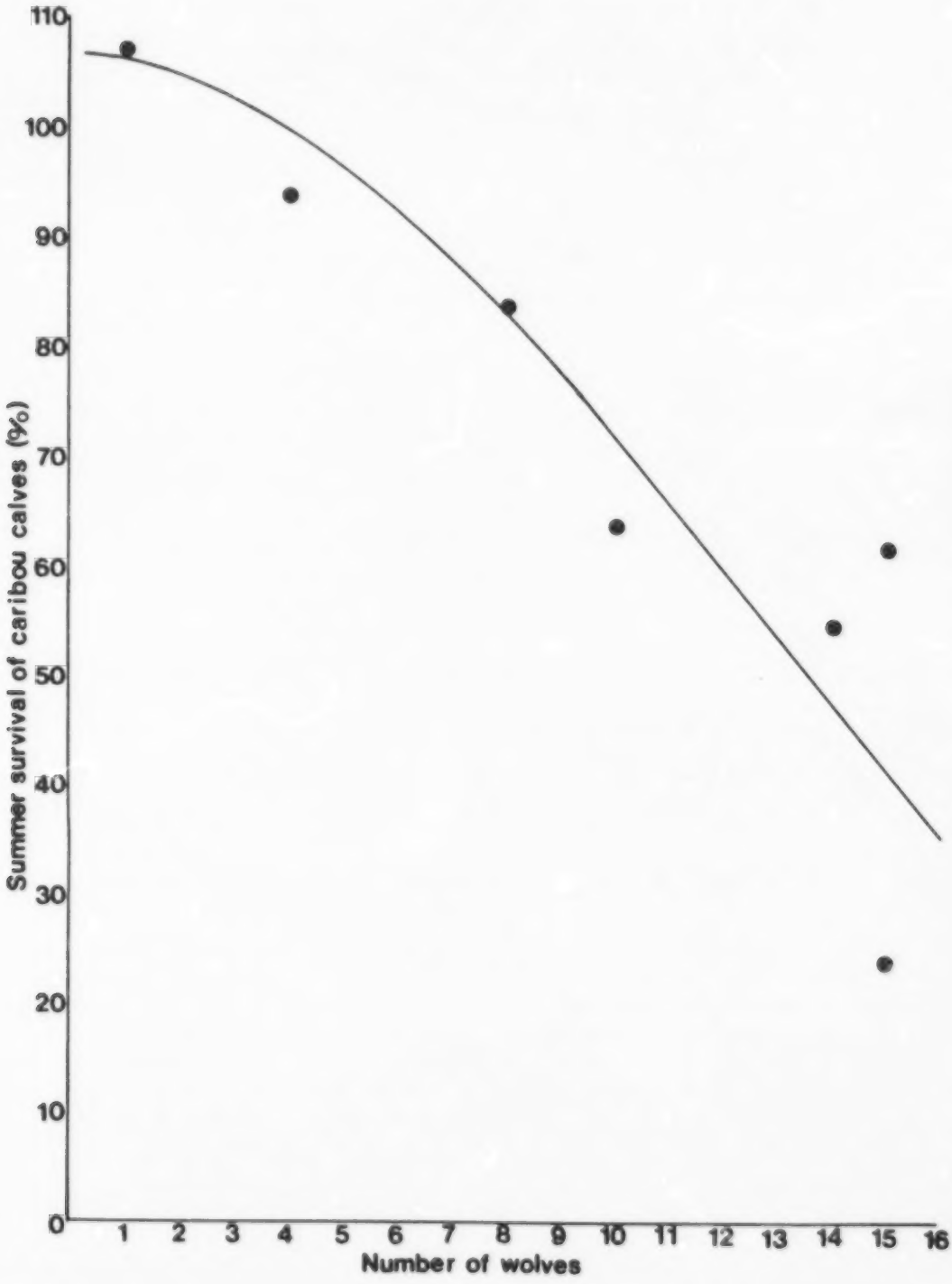

Figure 9. Relationship between summer survival of caribou calves and wolf numbers on the Horseranch Range.

Table 1. Wolf status in the Kechika study area, February-March, 1982-1984.

Treatment	Year	Area km²	Area mi²	No. of wolves	Km²(mi²) /wolf	No. of wolf packs[a]	Km²/ pack	Wolves/ pack
Untreated	1982	6010	2320	65	92 (36)	11 (+1 single)	546	5.8
	1983	2720	1050	57	48 (18)	8 (+2 singles)	340	6.9
	1984	3510	1355	71	49 (19)	10 (+1 single)	351	7.0
Pre-reduction	1982	3830	1480	88	44 (17)	13	295	6.8
	1983	7120	2750	107	67 (26)	21 (+5 singles)	339	4.9
	1984	9960	3846	138	72 (28)	29 (+7 singles)	343	4.5
Post-reduction	1982	3830	1480	18	213 (82)	4 (+1 single)	958	4.3
	1983	7120	2750	18	396(153)	5 (+4 singles)	1425	2.8
	1984[b]	9960	3846	37	269(104)	-	-	-

[a] excludes single wolves
[b] no packs evident following reduction

Table 2. Wolf status in Kechika study area, 1984 - 1985 winter

Status	Area km²	Area mi²	No. of wolves	Km²(mi²) /wolf	No. of packs	Km² /pack	Wolves /pack[a]
1984 removal area	10000	3850	111	90(35)	25(+6 single)	400	4.2
1984 untreated area	8400	3250	131	64(25)	15(+3 single)	560	8.5
Post reduction	18400	7100	85	216(84)	12(+3 single)	1530	6.8

[a] excludes single wolves

Table 3. Wolf status in the Blue-Jennings area, February-March 1985.

Category	Value
Land area	6500 km^2 (2500 mi^2)
Number of wolf packs	12 plus 1 single
Number of wolves	100
Area per pack[a]	541 km^2 208 mi^2)
Area per wolf	65 km^2 (25 mi^2)
Wolves per pack[a]	8.25

[a] excludes singles

Table 4a. Moose population composition for the Kechika and Blue-Jennings area in November 1984.

Area	No. of Cows(2+yrs)	Bulls (2+) /100 cows	Yearlings[a] /100 cows	Calves /100 cows	Total Classified
Pre-1984 reduction	77	47(36)[b]	55(42)	61(47)	202
1984 reduction extension	74	46(34)	11(8)	38(28)	144
Blue Jennings unreduced	71	65(46)	11(8)	8(6)	131

[a] assumes a 50:50 sex ratio.
[b] number of animals classified in parentheses.

Table 4b. Chi square contingency table for Table 4a.

Areas Compared	χ^2	df	P
YEARLINGS TO COWS			
All areas	26.790	2	<.001
1984 reduction extension vs. Blue Jennings	.006	1	.535
Pre 1984 reduction vs. 1984 reduction extension and Blue Jennings unreduced	26.784	1	<.001
CALVES TO COWS			
All areas	22.030	2	<.001
Pre 1984 reduction vs. 1984 reduction extension	2.757	1	.110
Pre 1984 reduction and 1984 reduction extension vs. Blue Jennings unreduced	19.273	1	<.001

Table 5a. Moose population composition for the Kechika and Blue-Jennings areas in February-March 1985.

Area	No. of Cows (2+yrs)[a]	Bulls(2+yrs) /100 cows	Calves /100 cows	Total Classified
Pre 1984 reduction	84	30(25)[b]	60(50)	159
1984 reduction extension	76	38(29)	38(29)	134
Blue Jennings unreduced	74	47(35)	5(4)	113

[a] assumes that adult (2+) to yearling ratio is unchanged from autumn
[b] number of animals classified in brackets.

Table 5b. Chi square contingency table for cows and calves in Table 50.

Areas Compared	χ^2	df	P
All areas	26.592	2	<.001
Pre 1984 reduction vs. 1984 reduction extension	2.500	1	.1101
Reduction areas vs. Blue Jennings unreduced	24.092	1	<.001

Table 6. Estimated number of February-March calves per 100 adult (2+) cow moose and previous spring wolf densities for the Kechika and Blue Jennings over time.

Year	Pre-1984 Reduction		1984 Reduction Extension		Blue Jennings	
	km^2/wolf (mi^2/wolf)	Moose calves	km^2/wolf (mi^2/wolf)	Moose calves	km^2/wolf (mi^2/wolf)	Moose calves
1982	44(17)[a]	12	93(36)[a]	19		
1983	213(82)	33	93(36)	12		
1984	396(153)	58	48(18)	6		
1985	302(117)	60	296(104)	38	64(25)	5

[a] unknown so necessary to use the value for the subsequent winter

Table 7a. Response of mountain sheep to differing wolf treatments, February-March 1985.

Area	Ewes (2+yrs)	No. /100 ewes (2+yrs) Lambs	Yearlings	Sample size
Pre 1984 reduction	591	43.7 (258)[a]	19.8 (117)	966
1984 reduction extension	118	49.2 (58)	11.9 (14)	190
1985 reduction extension	71	21.1 (15)	8.4 (6)	92
Blue Jennings unreduced	150	20.7 (31)	4.0 (6)	187

[a] sample size in parentheses

Table 7b. Chi-square contingency table for Table 7a.

Areas compared	χ^2	df	P
EWES TO LAMBS			
All areas	19.907	3	<.001
Pre-1984 reduction vs. 1984 reduction extension	.450	1	.509
1985 reduction extension vs. Blue Jennings unreduced	.004	1	.506
Pre-1984 reduction and 1984 reduction extension vs. 1985 reduction extension and Blue Jennings unreduced	19.45	1	<.001
EWES TO YEARLINGS			
All areas	21.298	3	<.001
1984 reduction extension vs 1985 reduction extension vs Blue Jennings unreduced	5.005	2	.081
Pre-1984 reduction vs. 1984 reduction extension, 1985 reduction extension, and Blue Jennings unreduced	16.295	1	<.001

Table 8. Horseranch Range caribou, October 1984.

Category	Number
Bulls (1+ yrs)	40
Cows (1+ yrs)	136
Calves	33(15.8)[a]
Total	209

[a] % calves of total in parentheses

Table 9. October herd counts of the Horseranch Range caribou, 1978-1984.

Year	Number				% of Calves	Calves/ 100 cows
	Cow(1+yrs)	Bull(1+yrs)	Calf	Total		
1978	182	37	44	263	17	24
1979	187	40	47	274	17	25
1980	183	78	50	311	16	27
1981	196	97	36	329	11	18
1982	208	115	14	337	4	7
1983	178	57	15	250	6	8
1984	136	40	33	209	16	24

Table 10. Neonatal calf proportions for the Horseranch Range caribou and spring snowpacks, 1978 - 1982.

Year	Estimated No. of Cows[a]	No. of Calves Seen	Calves/ 100 Cows	Snowpack[b]
1978	182	80	44	50
1979	184.5	49	27	136
1980	185	47	25	97
1981	191.5	42	22	112
1982	202	21	10	161

[a] An average of the previous and subsequent fall estimate of cows (except 1978 where the 1977 cow number is not available so 1978 alone is used).
[b] April 1 Dease Lake snowpack as a percent of average (to 1985)

Table 11. Calculated (from equation B) neonatal calf proportions for Horseranch Range caribou, 1983-1984

Year	Snowpack[a]	Calculated calves /100 Cows
1983	72	36
1984	59	40

[a] as in Table 10

Table 12. Summer survival of Horseranch Range caribou and spring wolf numbers, 1978 - 1984.

Year	Estimated % summer survival of caribou calves	No. of wolves
1978	55	14
1979	94	4
1980	107	1
1981	84	8
1982	64	10
1983	24	15
1984	62	15

Table 13. Spatsizi caribou, October 1984.

Category	Number
Bulls (1+ yrs)	233
Cows (1+ yrs)	429
U/c adult (1+ yrs)	240
Calves	139 (13.3)[a]
Total	1041

[a] % calves of total in parentheses

CONCLUSIONS

This project still has several years to completion; however, several features are becoming apparent.

1. There is a very strong positive response in moose, mountain sheep, and caribou juvenile survival when and where wolf numbers are lowered. This highlights the role of the wolf in the initial declines and indicates the utility of lowering wolf numbers as a management tool.

2. It appears that the larger the reduction area the less recolonization of the area within one year. This indicates that the larger the removal area, the lower the subsequent annual cost per unit area. Further, the reduced immigration associated with the larger area removal increases the positive prey species response.

3. The long term viability of wolf populations in the reduction area is in no way threatened, as indicated through partial annual recoveries from reduction.

4. The present removal method is low in cost and is effective to the level necessary for the program.

5. The continuation of the program is recommended to allow:

   (a) recovery of the prey populations to predecline levels.
   (b) the accumulation of an adequate data base from which to derive final conclusions.

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